



Figure 23.1: A "bird's eye" view of the US Naval Observatory. In the middle at center is the administration building and the dome of the 12" refractor. To its right is the dome of the 26" refractor. The 1000 foot diameter grounds of the USNO were established in 1890 to protect sensitive instruments from the vibrations caused by carriage wheels along nearby roads. (U. S. Naval Observatory)

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14. ABSTRACT Founded in 1830 as the Depot of Charts and Instruments, the U.S. Naval Observatory (USNO) is one of the oldest continuously operational scientific institutions in the United States. Among its first tasks were testing, rating and evaluation of various US Navy equipment (such as ships' chronometers) as well as the dissemination of time, first through its historic time ball and later through direct input via the Western Union telegraph. Fundamental astrometry and maintenance of the Fundamental Reference Frame were among its earliest charters. There have been two main USNO campus locations since 1844: the first was a region of Washington still known as "Foggy Bottom" which it occupied until 1893, when the USNO moved to its current location at "Georgetown Heights". The activities and history of the USNO from approximately 1850 to 1950 are briefly described with special attention to double star work done from then to now.					
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23. U.S. Naval Observatory: The Move to Georgetown Heights and Double Star Work (1850–1950)

Brian Mason (Washington, D.C., USA)

Abstract

Founded in 1830 as the Depot of Charts and Instruments, the U.S. Naval Observatory (USNO) is one of the oldest continuously operational scientific institutions in the United States. Among its first tasks were testing, rating and evaluation of various US Navy equipment (such as ships' chronometers) as well as the dissemination of time, first through its historic time ball and later through direct input via the Western Union telegraph. Fundamental Astrometry and maintenance of the Fundamental Reference Frame were among its earliest charters. There have been two main USNO campus locations since 1844; the first was a region of Washington still known as "Foggy Bottom", which it occupied until 1893, when the USNO moved to its current location at "Georgetown Heights". The activities and history of the USNO from approximately 1850 to 1950 are briefly described with special attention to double star work done from then to now.

23.1 Early Years of the Observatory

The foundation of a National Observatory was proposed by U.S. President John Quincy Adams in 1825¹ but due primarily to his unpopularity was never initiated. The Navy, especially after the War of 1812, recognized the value of a facility to support navigation and founded the Depot of Charts and Instruments in 1830. An observatory in all but name, its capabilities in those areas were severely restricted due to staff shortages and frequent changes of temporary housing in the early part of the 19th Century. In the early years frequent trips to Europe were made by James Gilliss for the purchase of books and instruments, among them a 9.6" Fraunhofer refractor and a 5.3" Ertel transit from Merz & Mahler.

Finally the US Naval Observatory (USNO) was given a more permanent home in 1844 at a location in Washington with the astronomically ominous name of Foggy Bottom. Bordered on three sides by the Potomac River, a swamp (fed by a sewer) and a coal-gas conversion facility, the location, while substandard astronomically, was well-placed for ship captains to set their chronometers

with the dropping at noon of the time ball from the mast above the dome at the top of the Observatory. Despite purchasing much of the equipment of the observatory, being the last officer in charge of the Depot, and designing the observatory, James Gilliss was not selected as the first superintendent of the USNO. Instead, that distinction went to Matthew Fontaine Maury. While Maury learned the observational work of the USNO, he is most well known as the father of the new science of Oceanography.

In 1861, when Maury resigned his Navy Commission to fight with the Confederacy in the American Civil War, Gilliss was finally named superintendent of the USNO. Coming on board with an ambitious observing program, Gilliss' plans were placed on hold because of the Civil War need to supply charts and instruments for the greatly expanded navy. After having to wait seventeen years before coming to the helm of the USNO, and then not having time to engage in astronomy, were not the end of Gilliss' run of bad luck as he, like other USNO astronomers, died as a result of complications due to malaria carried by the indigenous *Anopheles mosquito*.² Fortunately before this, as a concession from Welles, Gilliss was allowed to hire two "professors of mathematics" to engage in astronomical work, and his choices were quite good ones: Asaph Hall and Simon Newcomb.

Hall, Newcomb and other staff members made frequent trips for the recording of solar eclipses and participated in the two transits of Venus that occurred in the 19th Century but their most significant contributions were in other areas. Newcomb, for his part, was a much better mathematician than observer, and while bad observing conditions were prevalent in Foggy Bottom, it wasn't the only reason for not observing, as Newcomb recalled in his memoirs:

*When either Hubbard or myself got tired, we could "vote it cloudy" and go out for a plate of oysters at a neighboring restaurant.*³

Meanwhile, despite early instrumentation being of primarily German or English origin, a domestic instrumentation source was soon available. Alvan Clark & Sons of Cambridge, Massachusetts, began work in op-

tics. After the quality of their telescopes was praised by English astronomer William Dawes, they began to get work worldwide building large telescopes, including in 1873, the 26" refractor of the U.S. Naval Observatory. During a close approach of the planet Mars in 1877, while Newcomb and his assistant Edward Holden were away from the USNO, Hall observed Mars and discovered Phobos and Deimos. But, in what should have been the most productive years of the 26", then the largest telescope in the world, its capabilities were severely compromised due to the poor observing conditions in Foggy Bottom. Shortly after the discovery of Phobos and Deimos, Admiral Rodgers set in motion the process that would eventually lead to the USNO moving to Georgetown Heights. Land was purchased in 1881, funds allocated from 1886 to 1891 and in 1893 the USNO moved to its current location in a rural, high point above Georgetown.⁴

In the half century between the establishment of the USNO at Foggy Bottom and that of the new USNO at Georgetown Heights, the design of large observatories changed rather dramatically. Gone was the single monolithic building (exemplified by the Paris Observatory) which housed all instruments and offices. Instead, observatories started resembling parks, with discrete buildings dedicated separately for daytime office work and nighttime observing.

In addition to compartmentalizing work done on the campus this had the additional benefit of isolating the observing from noise, light and vibrations associated with work done in the daytime. The Georgetown Heights campus of the USNO followed this "observatory park" motif, as seen in fig. 23.1, p. 216. In addition to the administrative building was a dome for a 12" refractor, a spacious library, a large dome for the 26", several transit houses, a clock vault, and other structures.

In keeping with the overall change in the design philosophy of observatories, the Dean of American Architects,⁵ William Morris Hunt was selected to design the USNO. Hunt is probably most well known as the architect who designed the pedestal of the Statue of Liberty. It somehow seems fitting that he is well known for providing a solid base for that iconic statue just as astrometry, the principal astronomical activity of the USNO, serves as the foundation of the "astronomical pyramid".⁶

At a more remote location, Georgetown Heights certainly had fewer distinguished visitors than visited Foggy Bottom,⁷ and astronomers were supplied housing on the grounds due to its remote location. Today, these former astronomical staff houses are occupied by Flag Officers of the US Navy and other high officers of the government, most recently the Vice President of the United States.⁸

The 26" telescope can still be used today whenever conditions allow (typically 200 nights per year) and is now exclusively used for the observation of bright ($V < 11$) double stars.

The astrometric workhorse of the USNO, the 6" transit circle was built in 1898 by Warner & Swasey and was used continuously by at least two shifts of observers per night making positional measurements until 1995. Astrometric catalogs derived from these positions were produced on a regular basis. It remained the most reliable and accurate of the transit circles used with single measurement errors in the neighborhood of 0.4".

The pole-to-pole program would have been the best celestial reference frame if the Hipparcos satellite had failed. With the demonstrated success of space-based wide-field astrometry the transit circle program was terminated. Shortly after the centennial observation with the 6" transit circle, the telescope was moved to the main lobby of the USNO's Administrative Building for display and educational purposes. The foundation and piers of the building and telescope remain, and will form part of an interpretive courtyard presently under design review. Currently, the USNO is leading the development of a small satellite dedicated to absolute astrometry.⁹

The history and architecture of the USNO are well-recognized and the site was nominated for designation as a National Historic Landmark.¹⁰

23.2 Double Star Work

The U. S. Naval Observatory has, for well over a hundred years, been involved in various programs related to the observation of double stars. One of the first orders of the superintendent of the USNO, Matthew Fontaine Maury to Sears Walker discusses what parameters should be observed:

Sir: I wish you to take charge of the equatorial for the present, and to prepare for a regular series of observations of double stars, clusters, nebulae, and lunar occultations.

The observations of double (and multiple) stars will embrace distance, angle of position, color, magnitude, and appearance . . .

Let your observations embrace every double star of which the larger is of the 10th magnitude or under.

Three observing techniques have been used at the USNO: visual micrometry, photography, and speckle interferometry.

23.2.1 Visual Micrometry

Visual micrometry is the most often used (59%) technique for long-focus (pointed) double star work, and is, fortunately and unfortunately, the one most influenced by the skill of a particular observer. The earliest work in micrometry was done at the Foggy Bottom site in the midst of the Civil War with the 9.6" refractor by Hall, Newcomb and James Ferguson. Later work in the late 19th and early 20th century was done by these and Hall, Jr., Holden and others, primarily with the 26" refractor. In the early years, the 26" was visited by the leading double star astronomers of the time. The first double stars discovered at the USNO were discovered



Figure 23.2: The Hunt designed building to house the 26" refractor in 1890 in the midst of construction and today. In the 1890 image at left rear are seen the initial work on the foundations of the main administrative building. Despite the rather significant change in local foliage, these are kept at a manageable height and about 200 nights per year are suitable for obtaining observations. (U. S. Naval Observatory)

by a visiting astronomer: Sherburne Wesley Burnham. This prolific double star astronomer visited the USNO in August 1874:

Passing through Washington, I spent a few days there, and through the courtesy of Admiral Davis, Superintendent of the United States Naval Observatory, I had the pleasure of using the magnificent 26" recently erected by the Messrs. Clark and Sons. I had only one good night, and the 14 double stars in the following pages were all observed on that occasion . . .

For double star work this instrument seemed to be perfect. I looked up many of the closest double stars I could think of without finding anything that at all approached the limit of the power of the telescope. In fact these objects were almost too easy to be interesting.¹¹

On that evening Burnham was hosted by a contemporary mentioned in the log book, Edward Holden, long before the founding of Lick Observatory or the Astronomical Society of the Pacific, then on the staff of the USNO. Burnham found the objects numbered 286 to 300 in his list that night.

While Hall is well known for his discovery of Phobos and Deimos, from 1875 to 1891 he made nearly five thousand measures of close or faint stellar companions. These were ideal targets for the large telescope and Burnham¹² includes Hall as one of the "leading observers" in his double star catalog. About 5% of all double star micrometry measures made from 1875–1900 were made at the USNO.

While Simon Newcomb also observed double stars with the 26", his primary target and the focus of his and Holden's work turned out to be undetectable. Newcomb and Holden were the first 26" observing team and wanted to make a significant discovery with the largest telescope in the world. Following the Clark discovery of the white dwarf companion to Sirius, Newcomb and Holden spent most of their time trying to resolve the suspected close pair to Procyon¹³ and failing to do so.

It would not be resolved until Schaeberle turned the 36" refractor at Lick, also a Clark refractor, on it in 1896.

In 1883 the USNO was host to the Director of the Imperial Observatory at Pulkovo, Otto Wilhelm von Struve and his son Hermann. The primary purpose of this visit was instrument evaluation preparatory to testing the 30" objective made by Alvan Clark & Sons for the Pulkovo Observatory. It is easy to imagine these two double star experts desiring to put the 26" through its paces by observing some close doubles. However, as the 26" log indicated, conditions were not favorable.

Following Hall's retirement there was a flurry of activity related to double stars led by the "Astronomical Director" Stimson Brown and assisted by T. J. J. See. Another well known double star observer, William Hussey, observed with Brown the night of June 20, 1899 at Georgetown Heights.¹⁴ However, many of these staff members departed in the wake of an attempt to place the USNO under civilian control.

In the early 20th century some micrometry of double stars was done by Burton, Wylie, Lyons and Markowitz, but the combination of redirected priorities and limited staff at the USNO as well as productive programs elsewhere led to it producing less than 1% of all double star measures in the first half of the 20th century.

When Kai Strand joined the staff of the USNO, the double star program began to re-emerge. Strand recruited Charles Worley, who came to the USNO from Lick in 1961. Shortly thereafter the recognized standard double star catalog, the *Index Catalogue of Visual Double Stars*, or IDS, was transferred from Lick to Washington and re-designated the *Washington Double Star Catalog*, or WDS. The WDS was by then the *International Astronomical Union* (IAU) official catalog,¹⁵ with the "Double Star Centre" [sic] at the USNO having the responsibility to maintain and deliver copies of the catalog, now done via internet. The USNO and the double star program have continued to have very

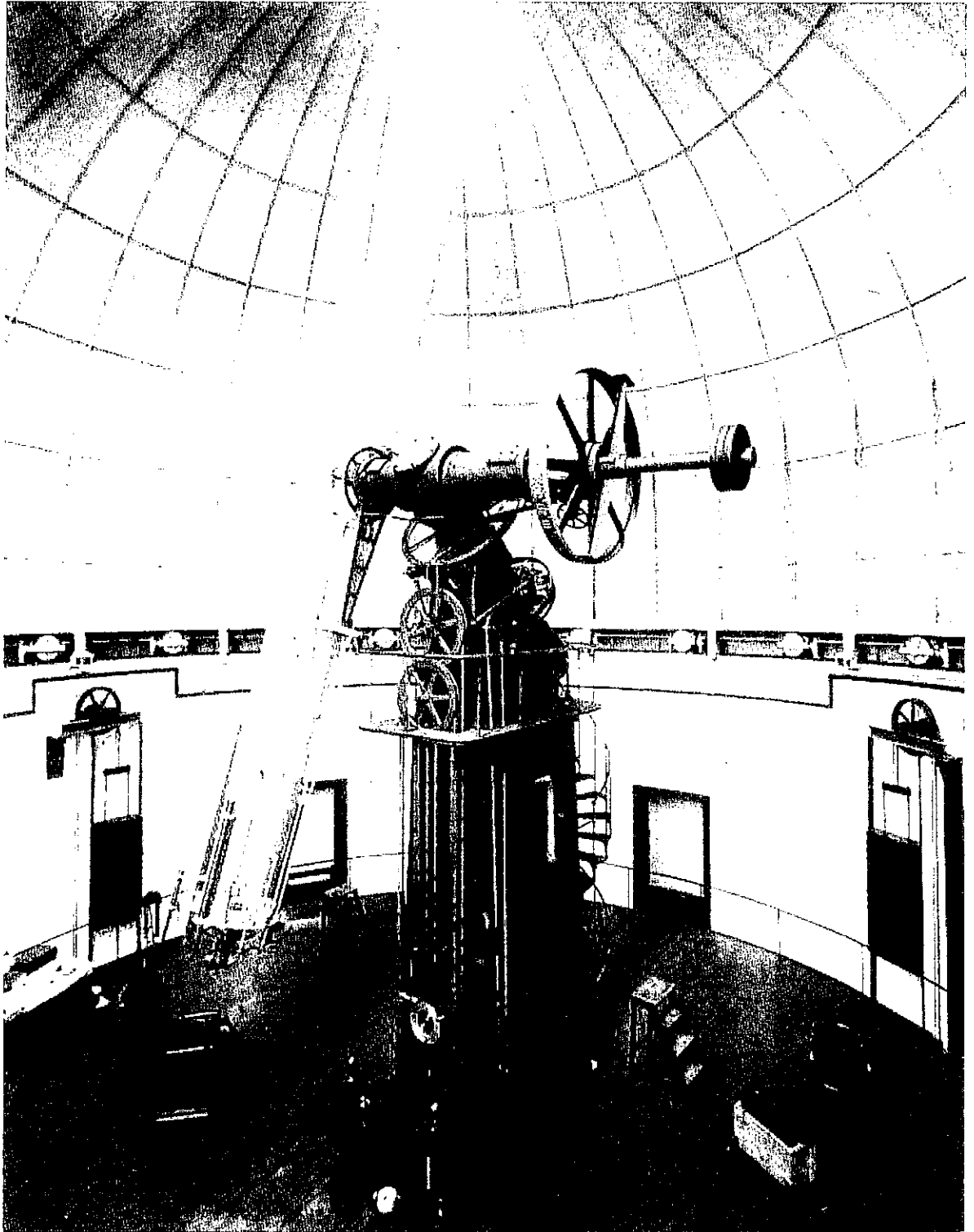


Figure 23.3: The 26" telescope in 1911. At the time it was still among the world's largest refractors, but with the Mt. Wilson 60" complete and work on the 100" progressing, the time of large refractors was passing. (U. S. Naval Observatory)

close ties with the IAU in general and Commission 26 (Double and Multiple Stars) in particular: at one time or other, USNO astronomers have been president of this Commission four times.

Worley began collaborations, first with William Finsen¹⁶ and later Wulff Heintz,¹⁷ in the production of catalogs of the orbits of binary stars. As an observer, Worley concentrated on obtaining very accurate measures of the closest, and most astrophysically significant, orbit pairs and to this day remains the third most prolific observer of double stars. From 1960 to 1990 over 20% of the total number of measures of doubles were done at the USNO. Micrometry ceased at USNO in 1990.

23.2.2 Photography

Observing double stars with the technique of multiple exposures with coarse gratings to reduce the magnitude error problem was developed by Ejnar Hertzsprung at Potsdam around 1914. Using this method, Strand initiated this program at the USNO in 1958. Utilizing cameras on the 24" Clark refractor at Lowell Observatory in Flagstaff, Arizona (led by Otto Franz) as well as the 26" in Washington (led by Jerry Josties) this program obtained over 10,000 very accurate measures of wider pairs before its termination in 1982. About 80% of these measurement were made with the 26". For a select group of wide pairs this method provided an objective technique for extremely accurate and precise measurements. This technique was most effective on pairs with a separation of at least a few arcseconds, allowing it some overlap with visual micrometry, although the core observing of these contemporary programs were non-overlapping. This relatively short activity period represented over 30% of all photographic measures of double stars ever made.

23.2.3 Double Star Observing Today

It is a credit to Charles Worley that, in the autumn of his scientific career and after making tremendous contributions in micrometry, he abruptly switched fields and embraced speckle interferometry for its abilities to resolve the closest and most astrophysically interesting pairs: his passion. This program was well suited for systems with separations as close as the Rayleigh limit of the telescope and as wide as the isoplanatic patch. For the 26" telescope this means that separations greater than 0.2" are resolvable. For closer pairs the speckle camera can, and has, been shipped to larger telescopes elsewhere in the US and overseas. In addition to continued measurement of close, orbit pairs, speckle is quite effective at confirming pairs discovered by satellite observation (Hipparcos, Tycho, HST-FGS), at a fraction of the cost of followup space observation.

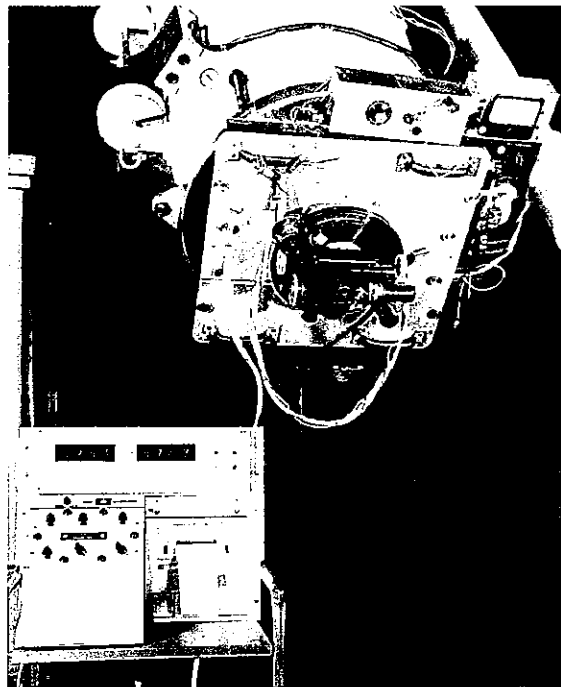
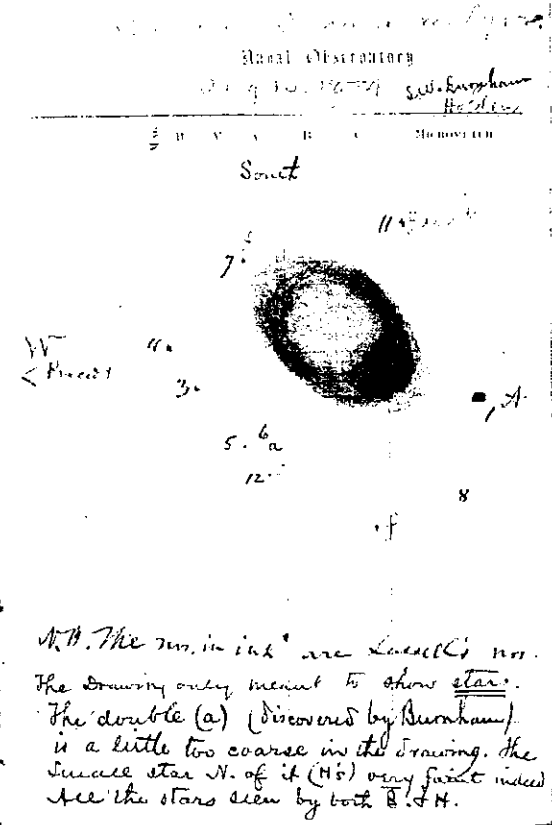


Figure 23.4: Discovery of the multiple system BU 293 in the observing logs of the 26" telescope in Washington; The semi-automatic micrometer. The eye was still used to judge positions, but digital encoders read out positions. Attached to the backend of the 26" refractor. (U. S. Naval Observatory)



Figure 23.5: The photographic double star camera attached to the back end of the 26" refractor. (U. S. Naval Observatory)

Another important facet of USNO double star work is that the leadership of the USNO in wide-field astrometry ensures that when these techniques measure separately the components of double stars they can be identified and added to the WDS.¹⁸ This process is ongoing.

The long history of the USNO's work in double star astronomy, the suitability of speckle interferometry for an urban setting, and the applicability of speckle to bright stars (which are the ones most often used for navigation) makes the long-term future of the program (and the continued use of the 26" Clark refractor) quite bright.

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1. Dick 2003, pp. 5.
2. Herman 1996, pp. 52. His apoplexy may have been due to overdosing with Quinine, a malaria treatment.
3. Newcomb 1903, pp. 102.
4. Dick 2003, pp. 298.
5. Dick 2003, pp. 311.
6. See Figure 1 of <http://www.scholarpedia.org/article/Astrometry>
7. Burlingame 1997, pp. 75.
8. Cleere 1989.
9. Gaume et al. 2009.
10. Butowsky 1989, pp. 15.
11. Burnham 1874.
12. Burnham 1906.
13. Davis 1876.
14. Brown 1900.
15. Pecker 1966, pp. 267.
16. Finsen & Worley 1970.
17. Worley & Heintz 1983.
18. e.g., Wycoff et al. 2006.

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